05-01-02

1762

EXPRESS MAIL NO.: EL 477 035 877 US

5/7/2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of: Chen et al.

Group Art Unit: 1762

Application No.: 10/081,768

Examiner: TBA

Filed: February 22, 2002

Attorney Docket No.: 11042-005

For: METHOD AND APPARATUS FOR FORMING A METALLIC FEATURE ON A SUBSTRATE

SUBMISSION OF CERTIFIED COPY OF PRIORITY DOCUMENT

Hon. Commissioner for Patents
Washington, D.C. 20231

Sir:

Applicants submit herewith a certified copy of Singapore Patent Application No. 200101072-7 filed February 23, 2001, priority benefit of which has been claimed for the above-identified application. It is requested that this submission be made of record in this file and that the examiner acknowledge receipt of this certified priority document.

No fee is believed to be due with this submission. Should any fee be required, however, please charge any such fee to Pennie & Edmonds LLP's Deposit Account No. 16-1150.

Respectfully submitted,

U.C. Reg. No. 36,196

Date: 4/30/02

Rory J. Radding 28,749
(Reg. No.)

PENNIE & EDMONDS LLP
1155 Avenue of the Americas
New York, New York 10036-2711
(212) 790-9090

Enclosure

REGISTRY OF PATENTS
SINGAPORE

This is to certify that the annexed is a true copy of the following Singapore patent application as filed in this Registry.

Date of Filing	:	23 FEBRAURY 2001
Application Number	:	200101072-7
Applicant(s)	:	INSTITUTE OF MATERIALS RESEARCH AND ENGINEERING
Title of Invention	:	METHOD AND APPARATUS FOR FORMING A METALIC FEATURE ON A SUBSRATE

Sharmaine Wu Shee Mei
Assistant Registrar
for REGISTRAR OF PATENTS
SINGAPORE

PATENTS FORM 1

Rule 19

SINGAPORE
PATENTS ACT
(CHAPTER 221)
PATENTS RULES

200101072-7
23 FEB 2001

The Registrar of Patents
Registry of Patents

REQUEST FOR THE GRANT OF A PATENT
THE GRANT OF A PATENT IS REQUESTED BY THE UNDERSIGNED ON THE BASIS OF THE PRESENT APPLICATION

I. Title of Invention	**METHOD AND APPARATUS FOR FORMING A METALLIC FEATURE ON A SUBSTRATE**	
II. Applicant(s) *(See note 2)*	*(a) Name*	**INSTITUTE OF MATERIALS RESEARCH AND ENGINEERING**
	Body Description/ Residency	**A PUBLIC COMPANY LIMITED BY GUARANTEE**
	Street Name & Number	**3 RESEARCH LINK SINGAPORE 117602**
	City	
	State	
	Country	**SINGAPORE**
	(b) Name	
	Body Description/ Residency	
	Street Name & Number	
	City	
	State	
	Country	
	(c) Name	
	Body Description/ Residency	
	Street Name & Number	
	City	
	State	
	Country	

23 FEB 2001
200101072-7

III. Declaration of Priority (see note 3)	*Country/Country Designated*	**N.A.**	*File no.*		
	Filing Date				
	Country/Country Designated		*File no.*		
	Filing Date				
	Country/Country Designated		*File no.*		
	Filing Date				

RECEIVED
MAY 03 2002
TC 1700

IV. Inventors (See note 4)		
(a) The applicant(s) is/are the sole/joint inventor(s).	[ ] *Yes*	[X] *No*
	[X] *Yes*	[ ] *No*
(b) A statement on Patents Form 8 is/will be furnished.		

V. Name of Agent (if any) (See note 5)	**ARTHUR LOKE BERNARD RADA & LEE**

VI. Address for Service (See note 6)	*Block/Hse No*		*Level No*	
	Unit No/PO Box	**#23-01**	*Postal Code*	**038989**
	Street Name	**9 TEMASEK BOULEVARD**		
	Building Name			

VII. Claiming an earlier filing date under section 20(3), 26(6) or 47(4). (See note 7)	*Application No*	**N.A.**
	Filing Date	

[Please tick in the relevant space provided]:

( ) Proceeding under rule 27(1)(*a*).
Date on which the earlier application was amended = _____
or
( ) Proceeding under rule 27(1)(*b*).

23 FEB 2001
200101072-7

VIII. Invention has been displayed at an International Exhibition (See note 8)	☐ *Yes* ☒ *No*
IX. Section 114 requirements (See note 9)	The invention relates to and/or used a micro-organism deposited for the purposes of disclosure in accordance with section 114 with a depository authority under the Budapest Treaty. ☐ *Yes* ☒ *No*

X. Check List

(To be filled in by applicant or agent)

A. The application contains the following number of sheet(s):-

1. Request	4	*sheets*
2. Description	20	*sheets*
3. Claim(s).	11	*sheets*
4. Drawing(s).	5	*sheets*
5. Abstract.	1	*sheets*

B. The application as filed is accompanied by:-

1. Priority document	
2. Translation of priority document	
3. Statement of Inventorship & right to grant	
4. International Exhibition Certificate	

XI. Signature(s)

(See note 10)

Applicant (a)	ARTHUR LOKE BERNARD RADA & LEE
Date	23 FEBRUARY 2001
Applicant (b)	
Date	
Applicant (c)	
Date	

23 FEB 2001
200101072-7

NOTES:

1. This form when completed, should be brought or sent to the Registry of Patents together with the prescribed fee and 3 copies of the description of the invention, and of any drawings.

2. Enter the name and address of each applicant in the spaces provided at paragraph II. Names of individuals should be indicated in full and the surname or family name should be underlined. The names of all partners in a firm must be given in full. The place of residence of each individual should also be furnished in the space provided. Bodies corporate should be designated by their corporate name and country of incorporation and, where appropriate, the state of incorporation within that country should be entered where provided. Where more than 3 applicants are to be named, the names and address of the fourth and any further applicants should be given on a separate sheet attached to this form together with the signature of each of these further applicants.

3. The declaration of priority at paragraph III should state the date of the previous filing, the country in which it was made, and indicate the file number, if available. Where the application relied upon in an International Application or a regional patent application e.g. European patent application, one of the countries designated in that application [being one falling under the Patents (Convention Countries) Order] should be identified and the name of that country should be entered in the space provided.

4. Where the applicant or applicants is/are the sole inventor or the joint inventors, paragraph IV should be completed by marking the 'YES' Box in the declaration (a) and the 'NO' Box in the alternative statement (b). Where this is not the case, the 'NO' Box in declaration (a) should be marked and a statement will be required to be filed on Patents Form 8.

5. If the applicant has appointed an agent to act on his behalf, the agent's name should be indicated in the spaces available at paragraph V.

6. An address for service in Singapore to which all documents may be sent must be stated at paragraph VI. It is recommended that a telephone number be provided if an agent is not appointed.

7. When an application is made by virtue of section 20(3), 26(6) or 47(4), the appropriate section should be identified at paragraph VII and the number of the earlier application or any patent granted thereon identified. Applicants proceeding under section 26(6) should identify which provision in rule 27 they are proceeding under. If the applicants are proceeding under rule 27(1)(*a*), they should also indicate the date on which the earlier application was amended.

8. Where the applicant wishes an earlier disclosure of the invention by him at an International Exhibition to be disregarded in accordance with section 14(4)(c), then the 'YES' Box at paragraph VIII should be marked. Otherwise the 'NO' Box should be marked.

9. Where in disclosing the invention the application refers to one or more micro-organisms deposited with a depository authority under the Budapest Treaty, then the 'YES' Box at paragraph IX should be marked. Otherwise the 'NO' Box should be marked.

10. Attention is drawn to rules 90 and 105 of the Patent Rules. Where there are more than 3 applicants, see also Note 2 above.

11. Applicants resident in Singapore are reminded that if the Registry of Patents considers that an application contains information the publication of which might be prejudicial to the defence of Singapore or the safety of the public, it may prohibit or restrict its publication or communication. Any person resident in Singapore and wishing to apply for patent protection in other countries must first obtain permission from the Singapore Registry of Patents unless they have already applied for a patent for the same invention in Singapore. In the latter case, no application should be made overseas until at least 2 months after the application has been filed in Singapore.

For Official Use

Application Filing Date: / /

Request received on : / /

Fee received on : / /

Amount :

*Cash/Cheque/Money Order No:

**Delete whichever is inapplicable*

METHOD AND APPARATUS FOR FORMING A METALLIC FEATURE ON A SUBSTRATE

THIS INVENTION relates to a method and apparatus for forming a metallic feature on a substrate, and in particular to a method and apparatus for forming fine metallic features in close proximity to one another on a substrate.

The formation of fine metallic features in close proximity to one another is of great commercial interest in several industries, most notably the printed circuit board (PCB), flexible circuit and packaging industries. The formation of smaller, more densely arranged components on the surface of a substrate allows the manufacture of PCB's that are cheap and operate quickly (due to the proximity of the components), and for flip chip applications the packaging industry requires the accurate patterning of solder bumps onto PCB's for connection to chips.

Many conventional methods of forming metallic features on substrates involve the use of photolithography to define a pattern on the substrate. However, this technique is cumbersome and expensive, and the size the of metallic features that can be produced thereby on, for example, PCB's is limited to around 30 μm and above. Moreover, the controlled formation of three-dimensional features (i.e. those which are raised above the surface of the substrate) is difficult using such conventional methods.

More recent techniques comprise the application of catalytic particles to the surface of a substrate by a soft stamp, the particles being applied in a pattern which corresponds to the metallic features that are to be created on the surface of the substrate. During subsequent electroless plating of the substrate, metal

will only adhere to the substrate where catalytic particles have been deposited. In this manner, small-scale metallic surface features can be created.

However, one drawback of this process is that the depth of the metallic features is limited by the amount of metal that can be deposited on a region of a substrate containing catalytic particles before lateral spreading of the metal takes place. This clearly places an upper limit both on the density of surface features that can be created using this technique and on the minimum distance between any two features.

A further drawback of this technique is that the catalytic particles (which often comprise palladium particles) do not adhere readily to the stamp, and must be precipitated onto the stamp in a relatively slow and impractical process.

It is an object of the present invention to seek to provide a method and apparatus for forming metallic features on a substrate that alleviate some or all of the above drawbacks.

Accordingly, one aspect of the present invention provides a method of forming a metallic feature on a substrate, comprising the steps of: providing a stamp having a raised region; depositing catalytic particles on a selected area of the stamp, including the raised region thereof; providing a substrate; applying the stamp to the substrate, such that the raised region of the stamp causes a corresponding indented region in the substrate and at least some of the catalytic particles are transferred to a selected area of the substrate; and plating the selected area of the substrate.

Advantageously, the step of depositing catalytic particles on the selected area of the stamp comprises the step of immersing at least the selected area of the stamp in a suspension comprising the catalytic particles.

Preferably, the step of immersing at least the selected area of the stamp in a suspension comprising the catalytic particles comprises the step of immersing at least the selected area of the stamp in an aqueous suspension comprising the catalytic particles.

Conveniently, the method further comprises the step of drying at least the selected area of the stamp, after immersion thereof in the suspension.

Advantageously, the step of drying at least the selected area of the stamp comprises the step of blow drying at least the selected area of the stamp with a gas.

Preferably, the step of blow drying at least the selected area with a gas comprises the step of blow drying the selected area with nitrogen, helium or air.

Conveniently, the step of depositing catalytic particles on the selected area of the stamp comprises the step of depositing polymer-stabilised catalytic particles on the selected area of the stamp.

Advantageously, the step of depositing polymer-stabilised catalytic particles on the selected area of the stamp comprises the step of depositing catalytic particles stabilised by polyvinylpyrrolidone, poly-2-vinylpyridine and polyvinyl alcohol on the selected area of the stamp

Preferably, the step of providing a substrate comprises the step of providing a substrate formed from a glass or a metal.

Conveniently, the step of providing a substrate comprises the step of providing a polymeric substrate.

Advantageously, the step of providing a polymeric substrate comprises the step of providing a substrate formed from a polystyrene, a polyimide, an acrylic or an epoxy.

Preferably, the step of applying the stamp to the substrate further comprises the step of heating at least one of the stamp or the substrate.

Conveniently, the step of heating at least one of the stamp or the substrate comprises the step of heating one of the stamp or the substrate to around the glass transition temperature of the substrate.

Advantageously, the method further comprises the step of modifying at least the selected area of the substrate to facilitate the deposition of the catalytic particles thereon.

Preferably, the step of modifying at least the selected area of the substrate comprises the step of chemically modifying the selected area of the substrate.

Conveniently, the step of chemically modifying at least the selected area of the substrate comprises the step of silanising at least the selected area of the substrate.

Advantageously, the method further comprises the step of removing some of the catalytic particles from the stamp.

Preferably, the step of removing some of the catalytic particles from the stamp comprises the steps of: applying an adhesive surface to the stamp; and subsequently removing the adhesive surface from the stamp.

Conveniently, the step of depositing catalytic particles on the selected area of the stamp comprises the step of depositing palladium-based catalytic particles on the selected area of the stamp.

Another aspect of the present invention provides a method of forming a metallic feature on a substrate, comprising the steps of: providing a mould, an inner surface thereof having a raised region, depositing catalytic particles on a selected area of the inner surface of the mould, including the raised region thereof; providing a substrate material; moulding the substrate material within the mould, such that a resulting substrate has an indented region corresponding to the raised region of the inner surface of the mould and at least some of the catalytic particles are transferred to a selected area of the substrate; and plating the selected area of the substrate.

Advantageously, the step of depositing catalytic particles on the selected area of the inner surface of the mould comprises the step of immersing at least the selected area of the inner surface of the mould in a suspension comprising the catalytic particles.

Preferably, the step of immersing at least the selected area of the inner surface of the mould in a suspension comprising the catalytic particles comprises the

step of immersing at least the selected area of the inner surface of the mould in an aqueous suspension comprising the catalytic particles.

Conveniently, the method further comprises the step of drying at least the selected area of the mould, after immersion thereof in the suspension.

Advantageously, the step of drying at least the selected area of the mould comprises the step of blow drying at least the selected area of the mould with a gas.

Preferably, the step of blow drying the selected area with a gas comprises the step of blow drying the selected area with nitrogen, helium or air.

Conveniently, the step of depositing catalytic particles on the selected area of the inner surface of the mould comprises the step of depositing polymer-stabilised catalytic particles on the selected area of the inner surface of the mould.

Advantageously, the step of depositing polymer-stabilised catalytic particles on the selected area of the inner surface of the mould comprises the step of depositing catalytic particles stabilised by polyvinylpyrrolidone, poly-2-vinylpyridine or polyvinyl alcohol on the selected area of the inner surface of the mould.

Preferably, the step of providing a substrate material comprises the step of providing a glass or metal substrate material.

Conveniently, the step of providing a substrate material comprises the step of providing a polymeric substrate material.

Advantageously, the step of providing a polymeric substrate material comprises the step of providing a substrate formed from a polystyrene, a polyimide, an acrylic or an epoxy.

Preferably, the step of providing a polymeric substrate material comprises the step of providing a thermoset substrate material, and wherein the step of moulding the substrate material comprises the steps of: moulding the substrate material in an uncured or partially cured state; and curing the substrate material in the mould.

Conveniently, the step of providing a polymeric substrate material comprises the step of providing a thermoplastic substrate material, and wherein the step of moulding the substrate material comprises the step of heating the substrate material to around the glass transition temperature thereof.

Advantageously, the method further comprises the step of removing some of the catalytic particles from the inner surface of the mould.

Preferably, the step of removing some of the catalytic particles from the inner surface of the mould comprises the steps of: applying an adhesive surface to the inner surface of the mould, and subsequently removing the adhesive surface from the inner surface of the mould.

Conveniently, the step of depositing catalytic particles on the selected area of the inner surface of the mould comprises the step of depositing palladium-based catalytic particles on the inner surface of the mould.

A further aspect of the present invention provides a method of forming a metallic feature on a substrate, comprising the steps of: providing a stamp; depositing polymer-stabilised catalytic particles on a selected area of the stamp; providing a substrate; applying the stamp to the substrate such that at least some of the polymer-stabilised catalytic particles are transferred to a selected area of the substrate; and plating the selected area of the substrate.

Advantageously, the step of depositing polymer-stabilised catalytic particles on the selected area of the stamp comprises the step of depositing catalytic particles stabilised by polyvinylpyrrolidone, poly-2-vinylpyridine or polyvinyl alcohol on the selected area of the stamp

Preferably, the selected area of the stamp comprises a raised region of the stamp.

Conveniently, the step of applying the stamp to the substrate comprises the step of pressing the stamp and the substrate against one another such that the raised region of the stamp causes a corresponding indented region in the substrate.

Advantageously, the step of depositing polymer-stabilised catalytic particles on the selected area of the stamp comprises the step of immersing at least the selected area of the stamp in a suspension comprising the polymer-stabilised catalytic particles.

Preferably, the step of immersing at least the selected area of the stamp in a suspension comprising the polymer-stabilised catalytic particles comprises the step of immersing at least the selected area of the stamp in an aqueous suspension comprising the polymer-stabilised catalytic particles.

Conveniently, the method further comprises the step of drying at least the selected area of the stamp, after immersion thereof in the suspension.

Advantageously, the step of drying at least the selected area of the stamp comprises the step of blow drying at least the selected area of the stamp with a gas.

Preferably, the step of blow drying at least the selected area of the stamp with a gas comprises the step of blow drying the selected area with nitrogen, helium or air.

Conveniently, the step of providing a substrate comprises the step of providing a glass or metal substrate.

Advantageously, the step of providing a substrate comprises the step of providing a polymeric substrate.

Preferably, the step of providing a polymeric substrate comprises the step of providing a substrate formed from a polystyrene, a polyimide, an acrylic or an epoxy.

Conveniently, the step of applying the stamp to the substrate further comprises the step of heating at least one of the stamp or the substrate.
Advantageously, the step of heating at least one of the stamp or the substrate comprises the step of heating at least one of the stamp or the substrate to around the glass transition temperature of the substrate.

Preferably, the method further comprises the step of modifying at least the selected area of the substrate to facilitate the position of the polymer-stabilised catalytic particles thereon.

Conveniently, the step of modifying at least the selected area of the substrate comprises the step of chemically modifying at least the selected area of the substrate.

Advantageously, the step of chemically modifying at least the selected area of the substrate comprises the step of silanising at least the selected area of the substrate.

Preferably, the method further comprises the step of removing some of the polymer-stabilised catalytic particles from the stamp prior to the application thereof to the substrate.

Conveniently, the step of removing some of the polymer-stabilised catalytic particles from the stamp comprises the steps of: applying an adhesive surface to the stamp; and subsequently removing the adhesive surface from the stamp.

Advantageously, the step of applying an adhesive surface to the stamp comprises the step of applying a patterned adhesive surface to the stamp.

Preferably, the step of depositing polymer-stabilised catalytic particles on the selected area of the stamp comprises the step of depositing palladium-based polymer-stabilised catalytic particles on the selected area of the stamp.

Another aspect of the present invention provides a stamp for application to a substrate, having a selected area comprising a raised region on a surface thereof

and at least the selected area of the surface having catalytic particles deposited thereon.

Conveniently, the catalytic particles are polymer-stabilised catalytic particles.

A further aspect of the present invention provides a stamp for application to a substrate, comprising polymer-stabilised catalytic particles deposited on a selected area of a surface thereof.

Advantageously, the selected area of the surface of the stamp comprises at least one raised region.

Another aspect of the present invention provides an apparatus for preparing a substrate, comprising: a stamp according to the above; and means to apply the stamp to a substrate.

Preferably, the apparatus further comprises means to selectively remove some of the catalytic particles from the stamp.

Conveniently, the apparatus further comprises means to plate the substrate.

Advantageously, the means to plate the substrate comprise means to electroless plate or immersion plate the substrate

In order that the present invention may be more readily understood, embodiments thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a cross-sectional view of a stamp;

Figure 2 shows a cross-sectional view of the stamp of Figure 1, with catalytic particles deposited thereon, embodying the present invention;

Figure 3 shows a cross-sectional view of the stamp of Figure 2 being applied to a substrate;

Figure 4 shows a cross-sectional view of the substrate of Figure 3 after application thereto of the stamp of Figure 2.

Figure 5 shows a cross-sectional view of the substrate of Figure 4 following metalisation thereof;

Figure 6 shows a cross-sectional view of a further stamp embodying the present invention;

Figure 7 shows a cross-sectional view of the stamp of Figure 6, with a length of adhesive tape applied thereto;

Figure 8 shows a cross-sectional view of the stamp of Figure 7, after removal of the adhesive tape;

Figure 9 shows a cross-sectional view of a further substrate, following application of the further stamp thereto and metalisation thereof.

Figure 10 shows a cross-sectional view of a third stamp embodying the present invention;

Figure 11 shows a cross-sectional view of the stamp of Figure 10 after application of an adhesive surface thereto;

Figure 12 shows a cross-sectional view of the stamp of Figure 11 being applied to a third substrate; and

Figure 13 shows the substrate of Figure 13 following metalisation thereof.

Turning firstly to Figure 1, a stamp 1 is shown. The stamp 1 may be formed from silicon, or may be formed from any other suitable material such as glass, a metal or a polymer. A stamping surface 2 of the stamp 1 is formed to have raised regions 3 thereon, there being sunken channels 4 between the raised regions 3. The pattern of raised regions 3 corresponds to a pattern of metallic features that are to be formed on a substrate.

In a first step of a method embodying the present invention, the stamping surface 2 of the stamp 1 is coated with a layer of catalytic particles 5, as shown in Figure 2. The stamp 1 now embodies the present invention. In a preferred embodiment, the catalytic particles 5 comprise nanometre-sized palladium particles. Advantageously, the catalytic particles 5 are coated with molecules of polyvinylpyrrolidone, poly-2-vinylpyridine or polyvinyl alcohol, which coating confers the beneficial effect of stabilising the colloidal suspension of the catalytic particles 5 against agglomeration.

The layer of catalytic particles 5 is deposited on the stamping surface 2 of the stamp 1 by immersion of the stamp 1 in a suspension of the catalytic particles 5. The catalytic particles 5 are adsorbed weakly to the stamping surface 2 of the stamp 1. After immersion in the suspension the stamp 1 is removed from the suspension and blown dry with a gas, such as nitrogen, helium or air.

Immersion of the stamp 1 in the suspension may take place for a few seconds, or for up to several minutes, as required.

In a subsequent step of the method of the present invention, the stamp 1 is pressed against a surface of a substrate 6, the stamping surface 2 of the stamp 1 being placed in contact with the substrate 6. This step is shown in Figure 3. The stamp 1 is pressed against the substrate 6 sufficiently forcefully that the raised regions 3 on the stamping surface 2 of the stamp 1 form corresponding indented regions 7 in the surface of the substrate 6, but not so forcefully that the sunken regions 4 of the stamping surface 2 come into contact with the surface of the substrate 6.

Advantageously, the substrate 6 is a polymeric substrate. In a preferred embodiment of the invention, the substrate 6 is formed from a thermoplastic material, and the stamp 1 is heated to around the glass transition temperature of the substrate material before or during application of the stamp 1 to the substrate 6. The material of the substrate 6 is selected to be sufficiently soft (or to become sufficiently soft on heating) that formation of the indented regions 7 by the raised regions 3 of the stamp 1 occurs readily.

Alternatively, the substrate 6 is formed from a partially cured thermoset polymer, and the substrate 6 is cured during or after the stamping process.

During the application of the stamp 1 to the substrate 6, the substrate 6 forms either direct or indirect bonds with the catalytic particles 5 on the stamping surface 2 of the stamp 1. These bonds are stronger than those between the catalytic particles 5 and the stamping surface 2 of the stamp 1. Hence, when the stamp 1 is removed from the substrate 6, many of the catalytic particles 5

remain in the indented regions 7 of the surface of the substrate 6, as shown in Figure 4.

In a preferred embodiment of the present invention, the surface of the substrate 6 is modified to facilitate the deposition of the catalytic particles 5 thereon. Such modification may be chemical (for instance, silanising of the substrate surface), and a skilled person will appreciate that there are several ways in which the substrate surface may be advantageously modified.

The substrate 6 is now ready for plating. The plating may be electroless plating, or may be performed by any other suitable method, for example immersion plating. The catalytic particles 5 perform as activators for the plating. Consequently, when the substrate 6 is plated, plating occurs only where the catalytic particles 5 are present on the surface of the substrate 6. It will be clear that, since the catalytic particles 5 are present only in the indented regions 7 of the surface of the substrate 6, metalisation of the surface of the substrate 6 during the plating process will only occur in the indented regions 7 thereof.

This means that, as metalisation of the surface of the substrate 6 progresses, the deposited metal will be contained within the walls formed by the non-indented regions of the surface of the substrate 6, and no lateral progress of the deposited metal across the surface of the substrate 6 will be possible. Figure 5 shows the substrate 6 after metalisation thereof, and it can be seen that the deposited metal 8 is restricted to the indented regions 7 of the surface of the substrate 6.

It will be appreciated that the above method allows the formation of metallic features on the surface of a substrate very close to one another, with very little

possibility of the metallic features interfering with one another, due to the presence of the walls of substance material therebetween.

In addition, the metallic features can be of relatively great depth, and the width of the features is independent of this depth, allowing greater control over the exact dimensions of the metallic features.

In another embodiment of the present invention, the catalytic particles 5 may be selectively removed from the surface of a stamp prior to the application of the stamp to the substrate. An example of this is shown in Figures 6 to 9.

Figure 6 shows a further stamp 9, which has a stamping surface 10 which is patterned to have raised regions 11 with sunken regions 12 therebetween. The stamping surface 10 of the further stamp 9 is coated with catalytic particles 5, as described above.

Prior to the application of the further stamp 9 to a substrate, a layer of adhesive tape 13 is placed over the stamping surface 10 of the further stamp 9, as shown in Figure 7. The catalytic particles 5 deposited on the raised regions 11 of the stamping surface 10 of the further stamp 9 will come into contact with the adhesive tape 13. However, the catalytic particles in the sunken regions 12 of the stamping surface 10 of the further stamp 9 do not come into contact with the adhesive tape 13.

The adhesive tape 13 is subsequently removed from the stamping surface 10 of the further stamp 9, and the catalytic particles 5 with which the adhesive tape 13 was in contact are also removed. Hence, as shown in Figure 8, the raised regions 11 of the further stamp 9 have no catalytic particles 5 thereon, but the

sunken regions 12 of the further stamp 9 have catalytic particles 5 adhered thereto.

The further stamp 9 is then applied to a further substrate 14. However, in contrast to the above-described application of the stamp 1 to the substrate 6, the further stamp 9 is pressed against the further substrate 14 with sufficient force for the entirety of the stamping surface 10 of the further stamp 9, including the sunken regions 12 thereof, to come into contact with the surface of the further substrate 14. Once the further stamp 9 is removed from the further substrate 14, catalytic particles 5 are only bonded to the further substrate 14 in regions thereof corresponding to the sunken regions 12 of the further stamp 9, as shown in Figure 9.

It will be appreciated that the selective removal of catalytic particles 5 from the surface of a stamp prior to application thereof to a substrate allows corresponding selective metalisation of the substrate during subsequent electroplating.

The above example also illustrates how the method of the present invention may be employed to create metallic features that protrude above the surface of a substrate. After application of the further stamp 9 to the further substrate 14, the surface of the further substrate 14 will comprise peaks (corresponding to the sunken regions 12 of the further stamp 9) and troughs (corresponding to the raised regions 11 of the further stamp 9). The peaks will be metallised. Hence, metallic features that protrude above the surface of the further substrate 14 may be created. The finely-controlled formation of such features as provided by embodiments of the present invention is useful in, for example, the provision of bumps on a PCB for connection to a chip.

In an alternative embodiment of the present invention, the stamp 1 or the further stamp 9 is provided as part of a mould, to be used in an injection or compression moulding process. Liquid substrate material is placed in the mould, and upon hardening of the substrate material a substrate having a surface with indented regions 7 corresponding to the raised regions 3, 11 on the stamping surface 2, 10 of the stamp 1 or the further stamp 9 is formed.

It will be appreciated that this method of forming a substrate may be employed with a wide variety of substrate materials. For instance, if the substrate material is a thermoset polymer, the substrate material is preferably moulded in an uncured or partially cured state and cured whilst in the mould. In contrast, if the substrate material is a thermoplastic polymer, the substrate material is preferably heated to just above the glass transition temperature thereof and cooled in the mould.

In another aspect, the present invention involves the use of polymer-stabilised catalytic particles. Known methods employ catalytic particles that are stabilised by surfactants, for example tetraoctadecylammonium bromide in toluene.

The use of polymer-stabilised catalytic particles, however, allows the particles to weakly adhere to a stamp within seconds, thus expediting the preparation of the stamp and reducing manufacturing time. Examples of suitable polymers that may be used to stabilise catalytic particles include polyvinylpyrrolidone, poly-2-vinylpyridine and polyvinyl alcohol. However, the present invention is not limited to these specific polymers.

This aspect of the present invention is not limited to use with a stamp having raised regions on a stamping surface thereof, and may be used with planar

stamps. Figure 10 shows a planar third stamp 15 with a layer of polymer-stabilised catalytic particles 16 deposited on a stamping surface 17 thereof.

An adhesive surface 18, having raised regions 19 thereon, is pressed against the stamping surface 17 of the third stamp 15 to selectively remove some of the polymer-stabilised catalytic particles 16 therefrom. In this embodiment of the invention, as will be seen below, the raised regions 19 of the adhesive surface 18 correspond to the gaps between metallic features that it is desired to form on a substrate. The adhesive surface 18 is removed from the stamping surface 16 of the third stamp 15, leaving polymer-stabilised catalytic particles 16 only on those regions of the stamping surface 17 of the third stamp that did not come into contact with the adhesive surface 18, i.e. those corresponding to the gaps between the raised regions 19 of the adhesive surface 18 as shown in Figure 11.

The third stamp 15 is then applied to a planar third substrate 20, as shown in Figure 12. In contrast to the above described embodiments, the pressing of third stamp 15 against the third substrate 20 does not create any significant indentations therein, as the stamping surface 17 of the third stamp 15 is substantially planar. As described above, the polymer-stabilised catalytic particles 16 will be transferred from the third stamp 15 to the third substrate 20. Following removal of the third stamp 15 from the third substrate 20, the third substrate 20 is electroless plated with a metal 21 resulting in metalisation of the third substrate 20 only in the regions thereof on which polymer-stabilised catalytic particles 16 have been deposited. (as shown in Figure 13).

The above invention is not limited to use in the PCB, flexible circuit and packaging industries, and it is envisaged that the present invention could also be used to pattern magnetic features (such as nickel/cobalt alloys) onto disks to

form patterned media disk drives. Alternatively, fine metal lines produced using the present invention could be used for optical or other gratings.

In the present specification "comprises" means "includes or consists of" and "comprising" means "including or consisting of".

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS

1. A method of forming a metallic feature on a substrate, comprising the steps of:

providing a stamp having a raised region;

depositing catalytic particles on a selected area of the stamp, including the raised region thereof;

providing a substrate;

applying the stamp to the substrate, such that the raised region of the stamp causes a corresponding indented region in the substrate and at least some of the catalytic particles are transferred to a selected area of the substrate; and

plating the selected area of the substrate.

2. A method according to Claim 1, wherein the step of depositing catalytic particles on the selected area of the stamp comprises the step of immersing at least the selected area of the stamp in a suspension comprising the catalytic particles.

3. A method according to Claim 2, wherein the step of immersing at least the selected area of the stamp in a suspension comprising the catalytic particles comprises the step of immersing at least the selected area of the stamp in an aqueous suspension comprising the catalytic particles.

4. A method according to Claim 2 or 3, further comprising the step of drying at least the selected area of the stamp, after immersion thereof in the suspension.

5. A method according to Claim 4, wherein the step of drying at least the selected area of the stamp comprises the step of blow drying at least the selected area of the stamp with a gas.

6. A method according to Claim 5, wherein the step of blow drying at least the selected area with a gas comprises the step of blow drying the selected area with nitrogen, helium or air.

7. A method according to any preceding claim, wherein the step of depositing catalytic particles on the selected area of the stamp comprises the step of depositing polymer-stabilised catalytic particles on the selected area of the stamp.

8. A method according to Claim 5, wherein the step of depositing polymer-stabilised catalytic particles on the selected area of the stamp comprises the step of depositing catalytic particles stabilised by polyvinylpyrrolidone, poly-2-vinylpyridine or polyvinyl alcohol on the selected area of the stamp

9. A method according to any previous claim, wherein the step of providing a substrate comprises the step of providing a substrate formed from a glass or a metal.

10. A method according to any one of Claims 1 to 8, wherein the step of providing a substrate comprises the step of providing a polymeric substrate.

11. A method according to Claim 10, wherein the step of providing a polymeric substrate comprises the step of providing a substrate formed from a polystyrene, a polyimide, an acrylic or an epoxy.

12. A method according to any preceding claim, wherein the step of applying the stamp to the substrate further comprises the step of heating at least one of the stamp or the substrate.

13. A method according to Claim 12, wherein the step of heating at least one of the stamp or the substrate comprises the step of heating one of the stamp or the substrate to around the glass transition temperature of the substrate.

14. A method according to any preceding claim, further comprising the step of modifying at least the selected area of the substrate to facilitate the deposition of the catalytic particles thereon.

15. A method according to Claim 14, wherein the step of modifying at least the selected area of the substrate comprises the step of chemically modifying the selected area of the substrate.

16. A method according to Claim 15, wherein the step of chemically modifying at least the selected area of the substrate comprises the step of silanising at least the selected area of the substrate.

17. A method according to any preceding claim, further comprising the step of removing some of the catalytic particles from the stamp.

18. A method according to Claim 17, wherein the step of removing some of the catalytic particles from the stamp comprises the steps of: applying an adhesive surface to the stamp; and subsequently removing the adhesive surface from the stamp.

19. A method according to any preceding claim, wherein the step of depositing catalytic particles on the selected area of the stamp comprises the step of depositing palladium-based catalytic particles on the selected area of the stamp.

20. A method of forming a metallic feature on a substrate, comprising the steps of:

providing a mould, an inner surface thereof having a raised region, depositing catalytic particles on a selected area of the inner surface of the mould, including the raised region thereof;

providing a substrate material;

moulding the substrate material within the mould, such that a resulting substrate has an indented region corresponding to the raised region of the inner surface of the mould and at least some of the catalytic particles are transferred to a selected area of the substrate; and

plating the selected area of the substrate.

21. A method according to Claim 20, wherein the step of depositing catalytic particles on the selected area of the inner surface of the mould comprises the step of immersing at least the selected area of the inner surface of the mould in a suspension comprising the catalytic particles.

22. A method according to Claim 21, wherein the step of immersing at least the selected area of the inner surface of the mould in a suspension comprising the catalytic particles comprises the step of immersing at least the selected area of the inner surface of the mould in an aqueous suspension comprising the catalytic particles.

23. A method according to Claim 21 or 22, further comprising the step of drying at least the selected area of the mould, after immersion thereof in the suspension.

24. A method according to Claim 23, wherein the step of drying at least the selected area of the mould comprises the step of blow drying at least the selected area of the mould with a gas.

25. A method according to Claim 24, wherein the step of blow drying the selected area with a gas comprises the step of blow drying the selected area with nitrogen, helium or air.

26. A method according to any one of Claims 20 to 25, wherein the step of depositing catalytic particles on the selected area of the inner surface of the mould comprises the step of depositing polymer-stabilised catalytic particles on the selected area of the inner surface of the mould.

27. A method according to Claim 26, wherein the step of depositing polymer-stabilised catalytic particles on the selected area of the inner surface of the mould comprises the step of depositing catalytic particles stabilised by polyvinylpyrrolidone, poly-2-vinylpyridine or polyvinyl alcohol on the selected area of the inner surface of the mould.

28. A method according to any one of Claims 20 to 27, wherein the step of providing a substrate material comprises the step of providing a glass or metal substrate material.

29. A method according to any one of Claims 20 to 28, wherein the step of providing a substrate material comprises the step of providing a polymeric substrate material.

30. A method according to Claim 29, wherein the step of providing a polymeric substrate material comprises the step of providing a substrate formed from a polystyrene, a polyimide, an acrylic or an epoxy.

31. A method according to Claim 29 or 30, wherein the step of providing a polymeric substrate material comprises the step of providing a thermoset substrate material, and wherein the step of moulding the substrate material comprises the steps of: moulding the substrate material in an uncured or partially cured state; and curing the substrate material in the mould.

32. A method according to Claim 29 or 30, wherein the step of providing a polymeric substrate material comprises the step of providing a thermoplastic substrate material, and wherein the step of moulding the substrate material comprises the step of heating the substrate material to around the glass transition temperature thereof.

33. A method according to any one of Claims 20 to 32, further comprising the step of removing some of the catalytic particles from the inner surface of the mould.

34. A method according to Claim 33, wherein the step of removing some of the catalytic particles from the inner surface of the mould comprises the steps of: applying an adhesive surface to the inner surface of the mould, and subsequently removing the adhesive surface from the inner surface of the mould.

35. A method according to any one of Claims 20 to 34, wherein the step of depositing catalytic particles on the selected area of the inner surface of the mould comprises the step of depositing palladium-based catalytic particles on the inner surface of the mould.

36. A method of forming a metallic feature on a substrate, comprising the steps of:

providing a stamp;

depositing polymer-stabilised catalytic particles on a selected area of the stamp;

providing a substrate;

applying the stamp to the substrate such that at least some of the polymer-stabilised catalytic particles are transferred to a selected area of the substrate; and

plating the selected area of the substrate.

37. A method according to Claim 36, wherein the step of depositing polymer-stabilised catalytic particles on the selected area of the stamp comprises the step of depositing catalytic particles stabilised by polyvinylpyrrolidone, poly-2-vinylpyridine or polyvinyl alcohol on the selected area of the stamp

38. A method according to Claim 36 or 37, wherein the selected area of the stamp comprises a raised region of the stamp.

39. A method according to Claim 38, wherein the step of applying the stamp to the substrate comprises the step of pressing the stamp and the substrate against one another such that the raised region of the stamp causes a corresponding indented region in the substrate.

40. A method according to any one of Claims 36 to 39, wherein the step of depositing polymer-stabilised catalytic particles on the selected area of the stamp comprises the step of immersing at least the selected area of the stamp in a suspension comprising the polymer-stabilised catalytic particles.

41. A method according to Claim 40, wherein the step of immersing at least the selected area of the stamp in a suspension comprising the polymer-stabilised catalytic particles comprises the step of immersing at least the selected area of the stamp in an aqueous suspension comprising the polymer-stabilised catalytic particles.

42. A method according to Claims 40 or 41, further comprising the step of drying at least the selected area of the stamp, after immersion thereof in the suspension.

43. A method according to Claim 42, wherein the step of drying at least the selected area of the stamp comprises the step of blow drying at least the selected area of the stamp with a gas.

44. A method according to Claim 43, wherein the step of blow drying at least the selected area of the stamp with a gas comprises the step of blow drying the selected area with nitrogen, helium or air.

45. A method according to any one of Claims 36 to 44, wherein the step of providing a substrate comprises the step of providing a glass or metal substrate.

46. A method according to any one of Claims 36 to 44, wherein the step of providing a substrate comprises the step of providing a polymeric substrate.

47. A method according to Claim 46, wherein the step of providing a polymeric substrate comprises the step of providing a substrate formed from a polystyrene, a polyimide, an acrylic or an epoxy.

48. A method according to any one of Claims 36 to 47, wherein the step of applying the stamp to the substrate further comprises the step of heating at least one of the stamp or the substrate.

49. A method according to Claim 48, wherein the step of heating at least one of the stamp or the substrate comprises the step of heating at least one of the stamp or the substrate to around the glass transition temperature of the substrate.

50. A method according to any one of Claims 36 to 49, further comprising the step of modifying at least the selected area of the substrate to facilitate the position of the polymer-stabilised catalytic particles thereon.

51. A method according to Claim 50, wherein the step of modifying at least the selected area of the substrate comprises the step of chemically modifying at least the selected area of the substrate.

52. A method according to Claim 51, wherein the step of chemically modifying at least the selected area of the substrate comprises the step of silanising at least the selected area of the substrate.

53. A method according to any one of Claims 36 to 52, further comprising the step of removing some of the polymer-stabilised catalytic particles from the stamp prior to the application thereof to the substrate.

54. A method according to Claim 53, wherein the step of removing some of the polymer-stabilised catalytic particles from the stamp comprises the steps of: applying an adhesive surface to the stamp; and subsequently removing the adhesive surface from the stamp.

55. A method according to Claim 54, wherein the step of applying an adhesive surface to the stamp comprises the step of applying a patterned adhesive surface to the stamp.

56. A method according to any one of Claims 36 to 55, wherein the step of depositing polymer-stabilised catalytic particles on the selected area of the stamp comprises the step of depositing palladium-based polymer-stabilised catalytic particles on the selected area of the stamp.

57. A stamp for application to a substrate, having a selected area comprising a raised region on a surface thereof and at least the selected area of the surface having catalytic particles deposited thereon.

58. A stamp according to Claim 57, wherein the catalytic particles are polymer-stabilised catalytic particles.

59. A stamp for application to a substrate, comprising polymer-stabilised catalytic particles deposited on a selected area of a surface thereof.

60. A stamp according to Claim 59, wherein the selected area of the surface of the stamp comprises at least one raised region.

61. An apparatus for preparing a substrate, comprising:
a stamp according to Claim 57 or 59; and

means to apply the stamp to a substrate.

62. An apparatus according to Claim 61, further comprising means to selectively remove some of the catalytic particles from the stamp.

63. An apparatus according to Claim 61 or 62, further comprising means to plate the substrate.

64. An apparatus according to Claim 63, wherein the means to plate the substrate comprise means to electroless plate or immersion plate the substrate.

65. A method substantially as herein before described, with reference to the accompanying drawings.

66. A stamp substantially as herein before described, with reference to the accompanying drawings.

67. An apparatus substantially as herein before described, with reference to the accompanying drawings.

68. Any novel feature or combination of features disclosed herein.

ABSTRACT

METHOD AND APPARATUS FOR FORMING A METALLIC FEATURE ON A SUBSTRATE

A method of forming a metallic feature on a substrate, comprising the steps of: providing a stamp having a raised region; depositing catalytic particles on a selected area of the stamp, including the raised region thereof; providing a substrate; applying the stamp to the substrate, such that the raised region of the stamp causes a corresponding indented region in the substrate and at least some of the catalytic particles are transferred to a selected area of the substrate; and plating the selected area of the substrate. [Figure 3]

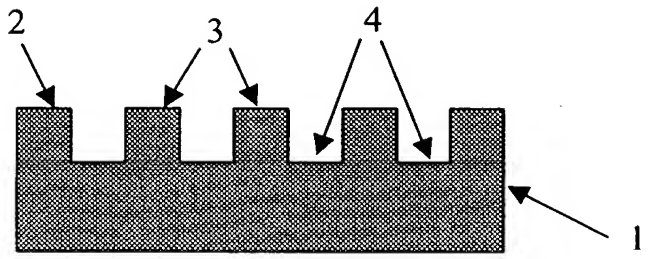

FIG. 1

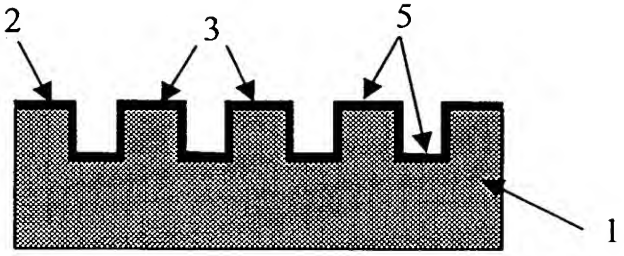

FIG. 2

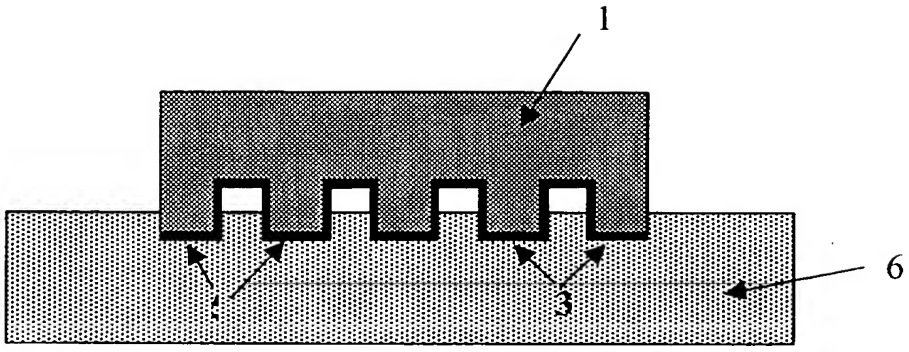

FIG. 3

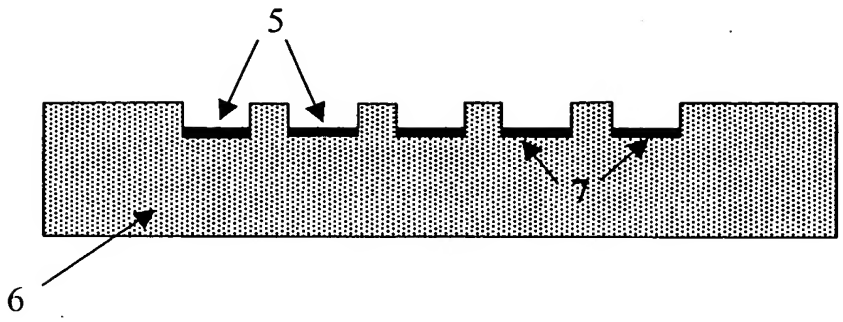

FIG. 4

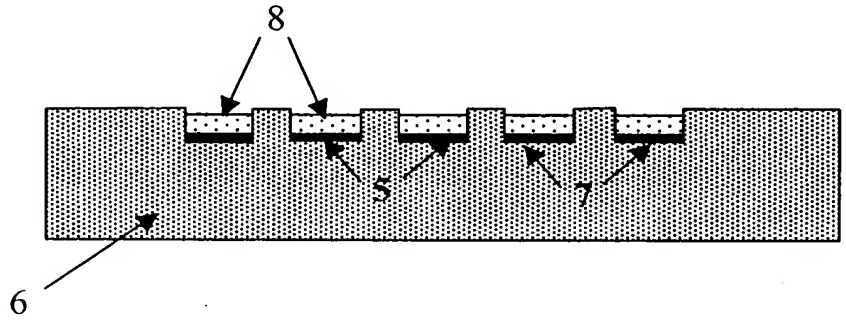

FIG. 5

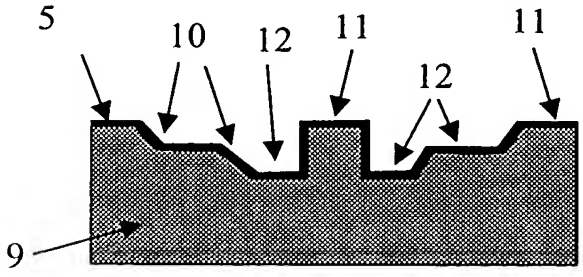

FIG. 6

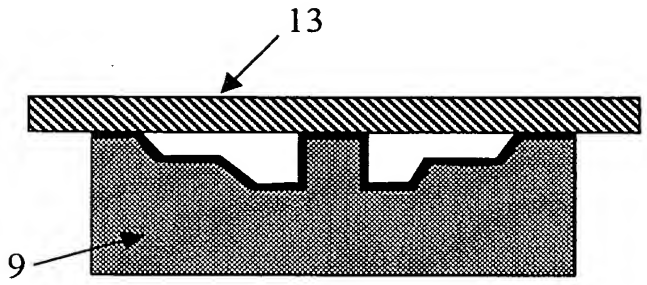

FIG. 7

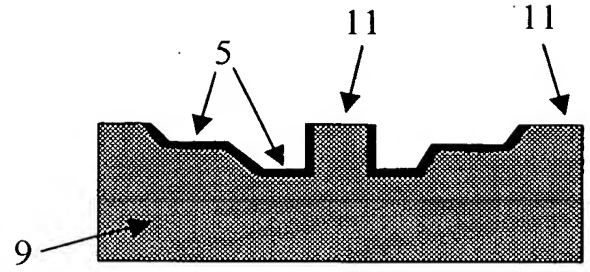

FIG. 8

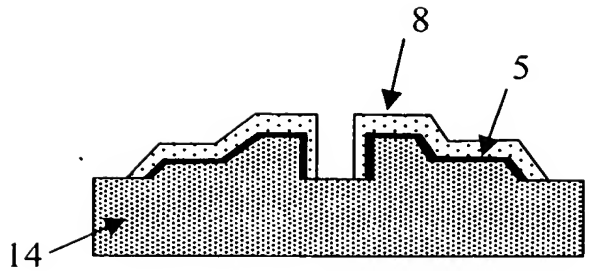

FIG. 9

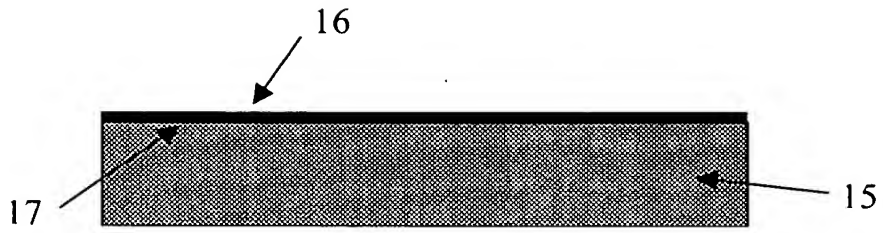

FIG. 10

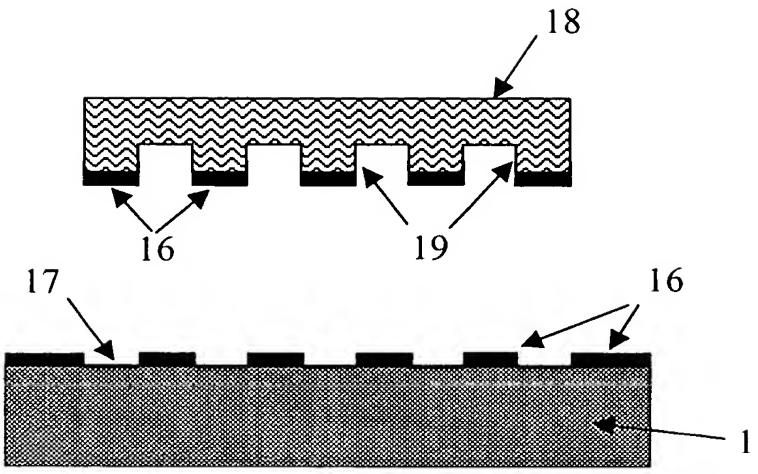

FIG. 11

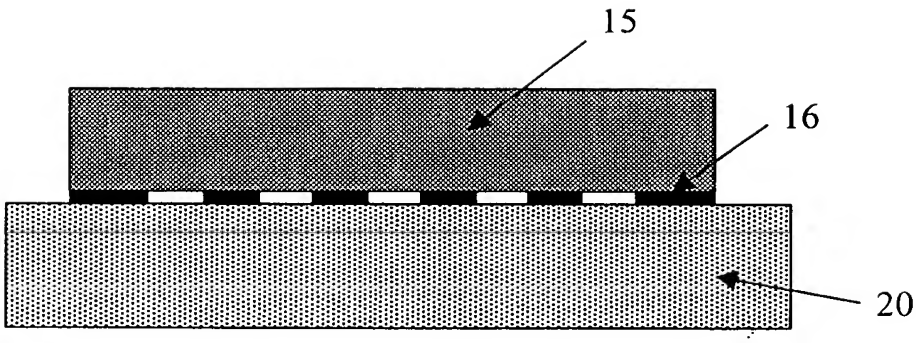

FIG. 12

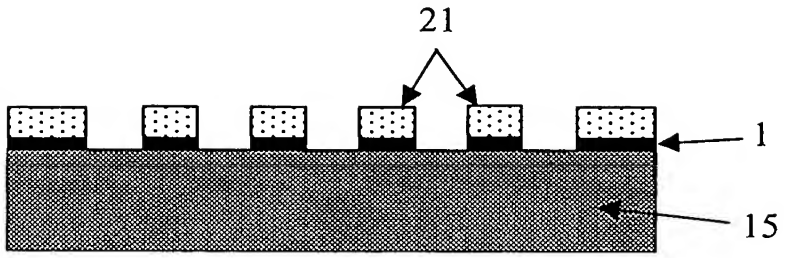

FIG. 13